How do mid-ocean ridges influence the geochemical composition of deep-sea sediments?

Background: Mid-ocean ridges emit hydrothermal plumes, which play an important role in modern ocean chemistry. Particulate heavy metal fallout creates important mineral reserves, and alkaline hydrothermal fluids may enhance carbonate preservation near the ridge. Mid-ocean ridges are also an important source for dissolved Fe, a critical micronutrient in the global ocean that may stimulate biological productivity in surface phytoplankton. The intern's research will be part of a project to explore the connection between climate change, seafloor volcanism, ocean productivity and atmospheric CO_2. We are working on new deep-sea sediment cores, recovered on a recent seagoing expedition in September 2014 to the Juan de Fuca Ridge. Previous work has identified time periods of volcanic activity associated with hydrothermal vents. Does this volcanic activity leave an imprint in the sediment composition? The student will focus on analyzing the sediment composition, including the concentrations of productivity indicators like opal, major elements like Fe and Mn, and calcium carbonate, to see how their inputs varied as climate changed and sea level rose and fell over the ridge during past glacial cycles.

Analysis Required: This project will require geochemical analyses of sediment potentially including coulometry ($CaCO_3$ %), alkaline extraction (opal %), and flux fusion (major elements). The student may also participate in sieving and sedigraph analyses of grain size. Lab work will require 20-30hrs/week for the first 6 weeks.

Prerequisities: No prior experience is necessary. Introductory coursework in the ocean, atmosphere and/or solid Earth (e.g., EESC V2100, EESC V2200) would be helpful. We will provide training in simple geochemical analyses, and the student should feel comfortable working in a chemistry lab. A careful, attentive student will rapidly develop the necessary expertise.

Mentors: Kassandra Costa: kcosta@ldeo.columbia.edu, 845-365-8454; Jerry McManus: jmcmanus@ldeo.columbia.edu, 845-365-8722

What is the ecology of tick-borne pathogens in the eastern United States?

Background: Tick-borne diseases are emerging worldwide and in particular in the United States. Anthropogenic changes such as forest fragmentation and climate change facilitating the spread of the blacklegged tick vector are partly responsible for this emergence. In addition to *Borrelia burgdorferi*, the Lyme diseaes agent – causing an estimated 300,000 Lyme disease cases/year, six other pathogens are known to infect this tick species. Our research addresses the question: Do interactions (facilitation or competition) with *Borrelia burgdorferi*, which often infects 80-90% of hosts in endemic areas, enhance the emergence of these newer pathogens? We have performed laboratory experiments and developed mathematical models showing that infection with *B. burgdorferi* makes hosts more suitable to transmit other pathogens, in particular *Babesia microti*, a malaria-like pathogen. Our goal is to describe the infection dynamics of the four most abundant tick-borne pathogens (*B. burgdorferi, B. microti, Anaplasma phagocytophilum and Borrelia miyamotoi*) to assess the presence and intensity of interactions. In summer 2016, we will continue ongoing studies collecting mouse and tick data in two ecologically contrasting areas: 3 sites in CT and 3 sites on Block Is., RI. This will be the 3rd year of data collection in CT and fourth on BI, which will allow us to start asking questions on the role of longer term ecological drivers such as climate and rodent population cycles on the abundance and interactions among these pathogens. The student working on this project during the summer field season will have access to previously collected data as well as their own collection to conduct these long-term dynamic studies.

Analysis Required: This project will require field work conducted between the end of May and end of September (3 months). Funded provided by LDEO will be supplemented by funding provided by the E3B Dept at Columbia Univ. in support of student's senior thesis. The student will be stationed on Block Island, RI, during this period and conduct 4-day sampling weekly sessions of mouse and ticks using standard methods. Laboratory analyses of these samples will be conducted during the subsequent senior year.

Prerequisites: None except willingness to perform field work under difficult conditions.

Mentor: Maria Diuk-Wasser: mad2256@columbia.edu, 212-854-3355

Pollution import? Investigating the origin of pollution episodes over Texas

Background. Ground-level smog is a pervasive air pollution problem over much of the densely populated eastern United States. Decreasing smog levels has proven to be a particularly challenging problem since these compounds primarily form through chemical reactions from precursor compounds in the presence of sunlight rather than being emitted directly from sources. On the basis of health evidence showing adverse health effects induced by exposure to ambient ground-level ozone, the U.S. Environmental Protection Agency has recently lowered the National Ambient Air Quality Standard (NAAQS) for ozone. The Texas Commission on Environmental Quality has noted several events where air monitors recorded ambient ozone levels approaching or exceeding this new NAAQS level. Our goal is to analyze these measurements, alongside a set of model simulations designed to attribute to sources originating from human activities within the United States versus "background sources" that include natural precursor emissions (e.g., lightning, wildfires, vegetation, soils) as well as international pollution (e.g., from Canada and Mexico).

Analysis required. Analyze daily measurements of ozone measured at a network of sites operated by U.S. Environmental Protection Agency Air Quality System and the Texas Commission on Environmental Quality and multiple simulations with the GEOS-Chem global atmospheric chemistry model. The daily data will need to be visualized in different ways (e.g., time series, maps, correlation analysis) to: (1) evaluate the ability of the model to represent and thus interpret the observations, and (2) examine contributions from various sources using the model simulations. Depending on the rate of progress, there are opportunities to extend this analysis to examine particulate matter, another form of air pollution that induces adverse health effects and reduces visibility.

Prerequisites. Prior data analysis experience, such as in excel**.** Familiarity with linux systems and experience manipulating and visualizing large datasets using a programming language such as IDL, matlab, or ncl preferable but not required.

Thesis Mentor: Arlene Fiore: amfiore@ldeo.columbia.edu, 845-365-8580

Is Sustainable Agricultural Development Possible? Monitoring environmental changes from large-scale cropping in the Eastern Savannas of Colombia

Background: Can we grow food without destroying the environment? In many regions of the world, agricultural expansion has been the cause of profound environmental impacts including deforestation, water contamination, erosion and biodiversity loss. Unfortunately in most cases, measures to deal with these impacts are implemented after the environment has been profoundly damaged. An unprecedented process of large-scale agricultural expansion is initiating in the tropical Eastern savannas of Colombia known as the Orinoquia. This largely unpopulated area is considered one of the last agricultural frontiers in the world given the availability of large areas highly suitable for mechanization and the current socially and politically stable conditions. At the same time, the region is very fragile given the very strong climatic seasonality, the very complex hydrological network and the high diversity of ecosystems and species. Our ongoing research aims to assess the impact of different strategies of agricultural expansion on natural resources in the region. The project involves the use of satellite imagery to identify where agriculture is expanding. Then we will combine this information with climatic information and ground measurements to assess the relative impacts of climate and different types of agriculture on soil, water and ecosystems. We require assistance in the collection and processing of ground data to identify the location, area, and agricultural practices of oil palm cultivations, forest plantations and rotational crops expanding in the region.

Analysis required: The research requires collecting field data to classify agricultural types, grasslands, forests, and other land covers in the Orinoquia region. Data to be collected includes the area of cultivations, crop types, average yields, and management techniques. The fieldwork will have a duration of 5 weeks. The rest of the summer will be spent processing the land cover information collected in the field along with remote sensing data to elaborate maps representing agricultural types and other land covers.

Prerequisites: Basic knowledge of GIS is desired.

Mentors: Victor Hugo Gutierrez-Velez, vhg2103@columbia.edu, 856-287-3422
Katia Fernandes, katia@iri.columbia.edu, 845-680-4449

How sensitive are eastern broadleaf forest trees to climate change?

Background: Can tree-ring isotopes and wood anatomy give important new insights into the sensitivity of eastern broadleaf forests to climate change? This is an outstanding question rarely addressed in this temperate, humid region. The project will investigate the adaptive physiological strategies of red oak (*Quercus rubra* L.) and yellow poplar (*Liriodendron tulipifera* L.) to climate change in eastern US at various spatiotemporal scales. The research will be conducted at Black Rock Forest NY and in the southern Appalachians Mountains GA. The study of distinct species and populations growing under different environmental conditions along a south to north gradient is crucial to understand different physiological strategies acquired over their evolutionary history. We will take advantage of the species contrasting drought–coping strategies in their stomatal conductance. Differences in stomatal conductance might influence differentially the isotopic signals of the fixed carbon and oxygen atoms, and tree water transport system. Stable isotope ratios in tree rings and wood anatomical structure will provide complimentary climatological and physiological information that are not available from tree-ring traditional metrics or ecophysiological experiments. Our integrative project will address issues of hydraulic transport, transpiration, photosynthesis and growth of two economically important tree species along a south–north transect in eastern US. The results are expected to have implications for landscape ecology, hydroclimate reconstructions, and ultimately for the improvement of the terrestrial carbon and hydrological models.

Analysis Required: Tree samples collected at Black Rock forest and in the southern Appalachians during a 3 to 4 day field trip will be analyzed for this project. Cores will be prepared, crossdated, measured (ring width and xylem structure) and then the tree rings will be cut for isotopic analysis. Cellulose extraction and wood anatomical measurements will be conducted at the LDEO campus. We will generate annually resolved carbon ($d^{13}C$) and oxygen ($d^{18}O$) stable isotopes, and vessels chronologies from tree-rings from these two species from 1950 to 2015. This period includes an extreme drought in the 1960s and a wet episode since the 1980s.

Prerequisites: None, although knowledge of dendrochronology, forest ecology and laboratory work is a plus.

Mentors: Mathieu Levesque mathieul@ldeo.columbia.edu, Laia Andreu-Hayles lah@ldeo.columbia.edu

Where and why is the seafloor of Long Island Sound changing?

Background: Coastal regions are changing in response to major storms, sea-level rise, changes in sediment supply, and human developments. Understanding how and where coastal systems are changing is important for predicting the impact of future changes and events. Over the last couple years, in the aftermath of the storm Sandy and as part of the Long Island Sound (LIS) Mapping Project, NOAA has been conducting high-resolution bathymetry surveys in large parts of Long Island Sound. As part of this project these new data would be compared with previous bathymetry data from 10-40 years ago to identify areas of significant seafloor changes in form of deposition and erosion. The identified changes in bathymetry could then be compared with existing sediment cores to verify the erosional or depositional nature of the identified changes. Subsequent analysis of spatial association with the location of tributary sources, human developments, and bottom shear stress of hydrographic models provided as part of the LIS mapping project might yield more insights in possible causes of the observed pattern of erosion and deposition.
It is possible that additional sediment cores might be acquired in the summer for some sections of the LIS. However, enough sediment cores are available for conducting this analysis for main areas.

Analysis Required: This project will require preparation and analysis of existing bathymetry data form various areas of Long Island Sound. The results will be compared to existing and potentially new sediment cores from the areas. The data will be loaded and analyzed using ArcGIS software package.

Prerequisites: Basic knowledge of ArcGIS is preferred but not required.

Thesis Mentors: Frank Nitsche, fnitsche@ldeo.columbia.edu (845-365-8746)

What is the paleovegetational history of the highest point in New Jersey?

Background: An early study of High Point State Park in New Jersey in the Shawangunk Mountains by William Niering (l953) is undated because it was taken prior to C-14 dating, but shows the analysis of several meters of lake and bog sediment atop grey clay. Pollen analysis at 1- foot intervals in the clay yielded very little information, but the brown lake sediment above the clay revealed that boreal forest (spruce, fir) was present in the late glacial, followed by an oak-dominated forest throughout the Holocene.
We retrieved a 6.5 meter sediment core in November 2015 and need a student interested in plant macrofossils to screen the sediment for plant macrofossils to enhance our understanding of vegetational change in the region. This study can help us to answer the following scientific questions:

(1) What are the first plants to arrive, and at what time – using the basal clay sediments? (2) Do larch and jack pine colonize the region as well as spruce and fir? (3) Does a white pine zone exist at this location, similar to Black Rock Forest and Mohonk? (4) When does oak dominate the forest? (5) When does hemlock decline? (5) When does southern white cedar and spruce arrive in the late Holocene? (6) When does the lake become a bog?

Field Research: Trip to Cedar Swamp, High Point to examine core site, collect modern plant material, and measure pH.

Analysis Required: Screening and picking samples, identification using binocular low-power microscope.

Prerequisites: None, although knowledge of plants is a plus.
Mentor: Dorothy Peteet, peteet@ldeo.columbia.edu, 845-365-8420

Can georeferenced maps on mobile devices enhance the environmental learning process in the field?

Background: Research has shown that the ability to think spatially, for example to link an abstract map with the real-world environment, poses a challenge for many people and needs to be addressed in education. The goal of this project is to create and make available GIS maps of a field station (Black Rock Forest) that highlight key geologic and geographical features of the forest and the research and educational activities going on. Black Rock Forest Consortium is a 501 (c) 3 not-for-profit organization with a mission of advancing scientific understanding of the natural world through research, education, and conservation programs. The Consortium maintains a 3,860-acre forest and a scientific field station in the Hudson Highlands, 60 miles north of New York City. Black Rock Forest is unparalleled resource for thousands of K-12, undergraduate, and graduate students and classes every year as well as the public in the region. The summer intern will create, edit existing, and convert geo-referenced maps so that they are available on-line and can be used on mobile devices in the field. He/she will also test how to best use mobile GPS devices in the challenging environment of Black Rock Forest (lots of trees, steep hillsides, narrow valleys, rocks with high magnetite content) and will develop educational activities around the maps and mobile apps that will allow students at different educational levels to improve their spatial thinking skills and learn about sustainability issues in the Hudson Highlands.

Analysis required: The project will require field trips to Black Rock Forest to gather GPS data, interface with the local GIS specialist, and test out educational modules on site.

Prerequisites: Ownership of a recent model smart phone required. A driver's license would be helpful. Some Geographical Information System (GIS) skills would be useful but are not required. Interest in education required.

Mentor: Martin Stute: martins@ldeo.columbia.edu, 845-365-8704

Can satellite observations help us better understand the air quality problem in India?

Background: India is home to some of the world's poorest air quality, with ambient concentrations of fine-mode particulate matter (PM2.5) often exceeding World Health Organization daily health guidelines by as much as an order of magnitude. While PM2.5 monitoring stations exist in some major cities and at US Embassies in India, the amount of available data across the Indian subcontinent is somewhat sparse, especially in comparison with data in the US or Europe. The use of satellite observations has been proposed as a potential source of air quality data where ground-based measurements are lacking, since satellites can provide essentially complete spatial coverage over a particular region of interest. Our work therefore aims to evaluate the relationship between ground-based PM2.5 measurements and satellite derived aerosol optical depth (AOD). In particular, we aim to answer the following question: How well do satellite AOD observations represent spatial and temporal variability of PM concentrations in India? Our results will shed light upon the applicability of using AOD as a proxy for PM2.5 and will provide insights into the successes and shortcomings of the proxy. Additional work (time permitting) may include extending our analysis to model simulated AOD and PM2.5, and using our data to evaluate an air quality model so that the model may be used for forecasts and projections of air quality in India in the future.

Analysis required: The student will aggregate and analyze NASA satellite observations, Indian PM data, and GEOS-Chem model output. This will include simple statistical analysis (mean, standard deviation) and plotting. More advanced analysis of the spatial and temporal trends in data, such as principal component analysis, may also be used. In this case, assistance (and code) will be provided to the student via the mentor. Mapping of observed and modeled PM concentrations over India will also be carried out with the assistance of the mentor. The student will participate and occasionally present in weekly teleconference meetings with researchers at Columbia and at IIT-Bombay in India. This project is part of a larger collaboration with IIT-Bombay.

Prerequisites: Proficiency with Microsoft Excel. Experience with more advanced data analysis software such as MATLAB, IDL, Python, or R is a plus but not required. Knowledge of air pollution science and/or meteorology is also a plus but not required.

Mentor: Dan Westervelt, Associate Research Scientist, danielmw@ldeo.columbia.edu, 845-365-8194